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MINE DESIGNER - AN AUTOMATED GRAPHICAL DATA GENERATION PROGRAM INTEGRATING NUMERICAL MODELLING WITH THE MINE DESIGN PROCESS (Version 1.3)

MRL 92-052(TR)

May 1992

by

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BEAP3D - BOUNDARY ELEMENT APPLICATION PACKAGE FOR THREE DIMENSIONAL ANALYSIS OF MINE STRUCTURES

The BEAP3D system consists of two separate modules, namely: MINE DESIGNER and BEAP. Two user manuals, published separately, are provided. The two user manuals are listed below:

1- MINE DESIGNER - An Automated Graphical Data Generation Program Integrating Numerical Modelling with the Mine Design Process.

2- BEAP - Boundary Element Analysis Program for Three Dimensional Analysis of Mine Structures.

Sun version

Hardware Requirements:

Minimum:	a Sun Sparcstation computer with colour graphics monitor, 200 megabytes of hard disk space, 8 megabytes of RAM.
Suggested:	a Sun Sparcstation computer with colour graphics monitor, 1 gigabytes of hard disk space, 16 megabytes of RAM.
Software Requirements:	SunOS 4.1.1 Operating System, or SunOS 4.1 Operating System plus OpenWindows Version 2.

IBM-PC Compatible version

Hardware Requirements:

Minimum:	an 80386 Personal computer, 80387 math coprocessor with Super VGA (1024x768 resolution) colour graphics adapter and monitor, mouse, 200 megabytes of hard disk space and 8 megabytes of RAM.
Suggested:	an 80486 Personal computer, 8514 compatible (1024x768 resolution) colour graphics adapter and monitor, mouse, 1 gigabytes of hard disk space and 16 megabytes of RAM.
Software Requirements:	Microsoft Windows 3.1 or above.

Reference to this manual should be quoted as follows: "MINE DESIGNER - AN AUTOMATED GRAPHICAL DATA GENERATION PROGRAM INTEGRATING NUMERICAL MODELLING WITH THE MINE DESIGN PROCESS (Version 1.3), Divisional Report MRL 92-052(TR)"

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1. INTRODUCTION

MINE DESIGNER (MD) is a data generation program for use with the three-dimensional boundary element analysis program BEAP. MD allows the user to graphically define a mining problem using advanced Computer Aided Design techniques from various stages along the mine design process.

The major aspects of mine design included in MD are: drill hole visualization, ore body definition and visualization, piping (shafts, drifts and raises) definition and visualization, and stope definition and visualization.

One of the major capabilities of MD that can be applied directly to the BEAP3D system is stope definition and visualization. All other data is maintained for the benefit of the user, to aid in the difficult task of defining a representation of a complex 3-Dimensional problem and to integrate numerical modelling with the mine design process. The program can also be used as a visualization tool of an overall mine, however, this is not the primary function of MD.

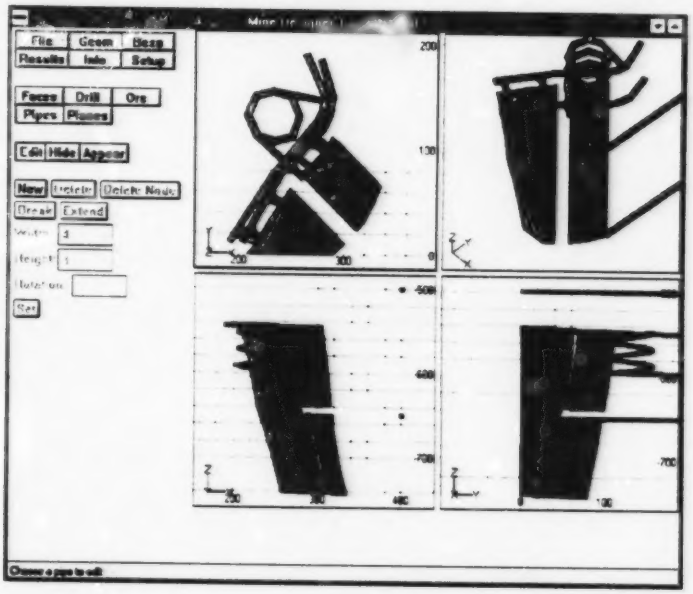


Figure 1 - Mine Designer main window

The first window which shows up on the screen is referred to as the Mine Designer Main window. The main window, with one of the five functions selected and shown in the upper left corner of the window is illustrated in Figure 1.

1.1 The BEAP3D Design Cycle

MD is an integral part of the BEAP3D Design Cycle as it is the starting point. The BEAP3D system has been designed to be as user-friendly and as automated as possible, however, the user is ultimately the key

to the accuracy and performance of the system. Most of the key decisions regarding the integrity and complexity of the problem are defined in the MD.

The BEAP3D system is intended to be used as a cycle, not a one-shot process. Mine design requires optimization and evolves with decision making. MD is intended to be a true editing tool to allow quick turnaround when trying different situations.

1.2 Program Layout

MD is designed to be as user-friendly as possible without limiting the functionality of the program. There are no complicated commands or keystrokes to remember. The program is designed to minimize the amount of steps required to complete a task while being as consistent and simple to use as possible.

The appearance of the program has been kept consistant in all implementations to minimize the learning curve required when switching from one computer to another. This unfortunatly breaks some of the style rules associated with the windowing systems. For example, MD does not have the traditional pop-down menu that MS-Windows applications usually have. In the future, some of these style issues may be addressed depending on the direction that the computer industry follows.

MD requires the use of a mouse for most of the operations of the program. Graphical User Interfaces are always heavily reliant on digitizers such as a mouse and MD is no exception. Users are expected to be familiar with the operation of a mouse.

2. GETTING STARTED

2.1 Program Execution

The current Sun implementation of MD requires SUN OpenWindows 2.0. OpenWindows must be loaded prior to MD. For the experienced user, it is possible to run MD on a Sun client and viewed from an X terminal. MD may also be viewed on a monochrome terminal, however, the results may be somewhat unappealing.

MD can be started from a command shell by simply executing "minedes", assuming that MD is located in the current directory or on the executable search path.

MD may also be executed from the OpenWindows File Manager. For more information, please refer to the documentation provided with OpenWindows.

The Windows version of MD requires MS-Windows version 3.1 or above. Windows must be loaded prior to MD. MD can then be run in the same way any other Windows Application is executed. Most users will start MD by simply double clicking on the MD icon in the Program Manager.

Currently the MD icon looks like:

MD's executable files consist of MINEDES.exe and various .DLL files. MINEDES.exe loades the .DLL program files during start up. Windows will notify the user if any of the files are missing.

2.2 Screen Layout

MD uses only one main window (sometimes called a Frame). This is intended to minimize the amount of window maintenance by the user. The main window contains three important areas: the dialogue menu, views and view response area. Figure 1 illustrates these areas.

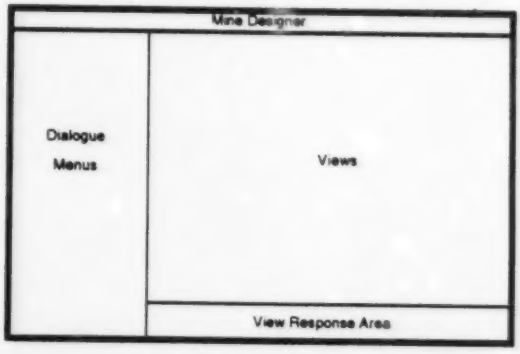


Figure 2 - the main window layout

The DIALOGUE MENU

The dialogue menu is more than just a means of accessing commands, it also controls the state of MD. The menu is described in greater detail later in this section.

The VIEWS

The views allow the user to continually view a representation of the current model as well as provide a graphical means of data selection and modification. It is imperative that the user be proficient in the use of the views as they provide most of the functionality and versatility of MD.

The VIEW RESPONSE AREA

From time to time, there will be a need to respond to questions from the program that cannot be accommodated by the dialogue menu. The view response area will reflect these questions.

2.3 Opening and Saving Sessions

All of the data regarding the makeup of a model are stored together in one session file. This file is a text file with the default extension ".DES". The file format for these files can be found in section ***.

Creating a new session

Select the *"File, New"* menu item to begin a new session. All data currently contained in MD is lost and the views are reset to a suitable position to start the model definition.

Opening a Session

Select the *"File, Open..."* menu item to open an existing session. The user is then prompted for the name of the session file to be loaded. The views are then adjusted so that the entire model is visible. All data previously contained in MD is lost.

Merging a Session

It is often useful to merge the contents of two smaller models. This is accomplished by opening the first session normally and then selecting the *"File, Merge..."* menu item to include the contents of the second. Merge performs the same function as Open except that the current contents of MD are not cleared prior to loading.

Saving a Session

Select the *"File, Save..."* menu item to save the current session. The user is then prompted for the name of the session file to be written to. The previous contents if any of the file are overwritten.

2.4 Using the Dialogue Menu

The dialogue menu has several purposes: it provides the direction or state of the program while at the same time providing most of the input fields associated with the model. The dialogue menu is arranged in what is often called a tree structure. Figure 3 illustrates the tree diagram for MD.

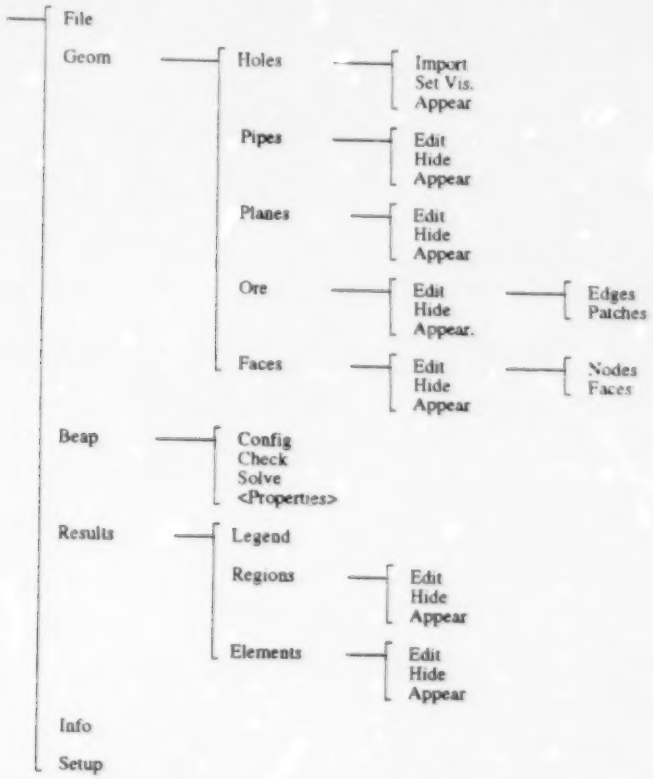


Figure 3 - The menu structure of MD

Only one part of the menu is visible at a time. For example, if the edges (i.e. boundaries) of an ore body are being edited, the visible part of the menu would be identified as *"Geom,Ore, Edit, Edges"*. Figure 4 shows the dialogue menu area for this example.

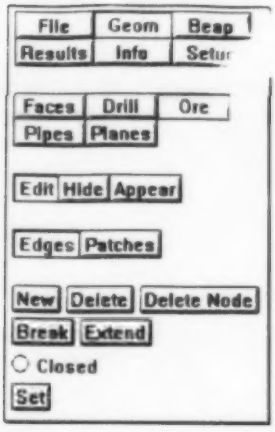


Figure 4 - Example of the Dialogue Menu for *"Geom, Ore, Edit, Edges"*.

To branch to a different part of the menu, simply click on the desired label. For example, to change from *"Geom, Ore, Edit, Edges"* to *"Geom, Ore, Appear."*, simply press the *"Appear."* label.

All sub-branches are left as they were during menu changes. For example, if the *"Planes"* label was pressed and then the *"Ore"* label, the menu strip would then return the menu to *"Geom, Ore, Edit, Edges"*.

2.5 Object Appearance

It is often necessary to change the appearance of the mine data to help clarify the model. For example, it is convenient to make the ore body transparent when considering the position of the stope faces relative to the ore body so that the stopes "show through". The different appearances also affect the amount of time necessary to redraw a view.

To change the appearance of a data type, simply select the applicable *"Appear."* menu item and select the required appearance choice.

For all data types except drill holes, the available choices for appearance consist of: shaded, solid, transparent and wire frame. Drill hole appearance is described in detail in section 4.2. The following table describes the look and graphics speed for display of the different choices.

Appearance	Drawn as ... [speed 1-10]	
	in fast mode	in slow mode
"Shaded"	green shaded faces as if an imaginary light source was present [8]	same with full hidden surface removal [2]
"Solid"	solid coloured faces [8]	same with full hidden surface removal [2]
"Transparent"	hatched faces with objects behind partially showing through [6]	same with full hidden surface removal [2]
"Wire frame"	black lines [10]	same [3]
"Contoured"	solid faces with averaged colours [7]	solid faces with smooth coloured contours [1]

2.6 Object Visibility

It is often necessary to temporarily hide pieces of the model to speed up the regeneration of the graphics or remove obstructions. All data types can be temporarily hidden from the graphics.

To activate the visibility menu for a data type select the applicable *"Hide"* menu item. Four buttons become available: *"All Visible"*, *"All Invisible"*, *"Selected Visible"* and *"Selected Invisible"*. Any objects that are to be hidden will be visible as grey transparent objects, while all other objects will appear normal. When the *"Hide"* sub menu is not displayed the hidden objects will disappear.

Note: Some care must be taken to ensure that the appearance (as described above) of the data type is not transparent because it will be impossible to distinguish between the hidden and visible objects.

- *To make all objects of the data type visible or invisible:*
  - Press the *"All Visible"* or *"All Invisible"* button.

- *To make one objects of the data type visible or invisible:*
  - Click on the object in any of the views, then press the *"Selected Visible"* or *"Selected Invisible"* button.

- *To make a region of the data type visible or invisible:*
  - Click and Drag out a box around the objects to be affected and then press the *"Selected Visible"* or *"Selected Invisible"* button.

3. USING VIEWS

3.1 Views

The user can view the model through one or more views. Each view is a window with an axis and an optional grid and it can be oriented independently from any other views. The size and shape of a view depends on the size of the main window and the current view layout.

Although each view has an independent orientation, all views work together to provide a consistent means of graphical input.

3.1.1 Coordinate System

The coordinate system for MD adheres to the right hand rule with the z-axis representing elevation in the vertical direction. The axis in the bottom left corner of each view always reflects the orientation of the view. Figure 5 illustrates the coordinate system.

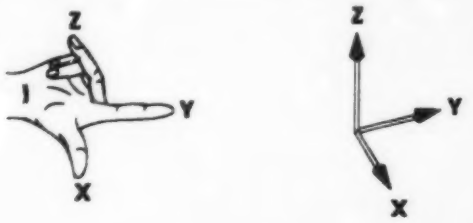


Figure 5 - the coordinate system

3.1.2 Eye Position, Rotation and Extents

The orientation of a view is defined by three properties: the eye position, current rotations and extents of the view.

- **Eye Position**

  The eye position defines a 3-dimensional point corresponding to the centre of the view.

- **Rotations**

  There are two rotations available to the user: the bearing and the dip. Limiting the user to only two rotations guarantees that the model will be upright and easily manipulated.

- **Extents**

  The extents of a view define the size of the model in the view. The horizontal and vertical extents are always adjusted to keep the model's aspect ratio correct.

  The third and more subtle extent is the thickness of the view. The thickness determines how much of the scene is visible in front and back of the eye position. A thickness of zero produces a cross section of the model.

Figure 6 illustrates the orientation properties of a view.

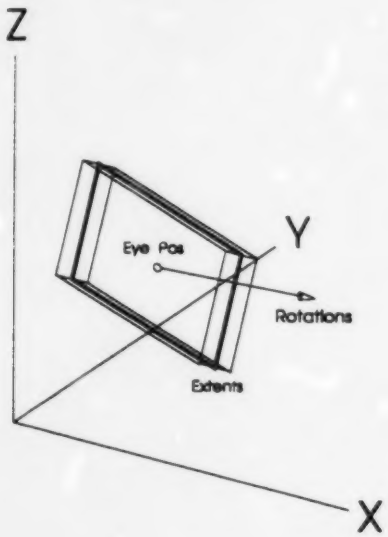


Figure 6 - View orientation properties

3.1.3 View Layout

The user is given a choice as to the layout of the views. The available configurations are illustrated below. Note the numbering of the views; when changing layouts, the views move to their respective places. The last arrangement (Maximized Window) is not really a layout but is included to show all possible configurations.

Quad Layout

(Default)

3 and 1 Layout

1 and 1 Layout

Maximized Window

3.2 View Controls

There are two different types of view controls: **menu controls** and **keyboard controls**. The menu controls typically include the more powerful and lesser used functions while the keyboard controls include the more interactive functions.

3.2.1 Menu Controls

Each view has a popup menu associated with it. This menu can be accessed by pressing the right mouse button while the mouse pointer is within the view. Figure 7 illustrates the menu.

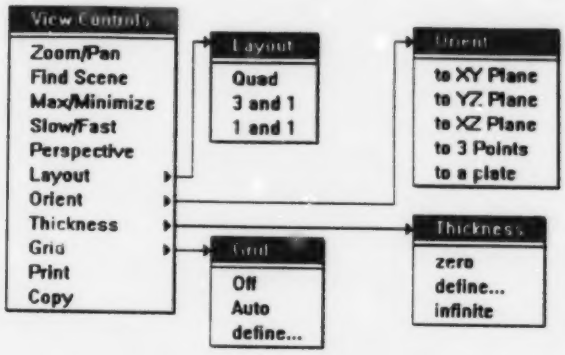


Figure 7 - The view control menu.

"Zoom/Pan"

This control is used to move the eye position and the horizontal and vertical extents. After selecting *"Zoom/Pan"* the user is expected to perform one of the following operations:

- *to Zoom In*: click and drag out a box with the left mouse button around the area of the view to zoom into.
- *to Zoom Out*: click and drag out a box with the right mouse button specifying the size that the currently visible area will become.
- *to Pan*: click on a point in the view with either the right or left button that will become the centre of the view.
- *to Cancel*: click on the centre mouse button to cancel the operation.

Note: zooming in perpective viewing

"Find Scene"

This control is used to change all extents such that the entire model is visible.

"Max/Minimize"

This control is used either to make the current view full size or to return the views to the current layout.

"Slow/Fast'

This control is used to toggle between slow and fast rendering. Slow rendering produces proper hidden surface removal at the cost of speed. Fast rendering is most useful for interactive sessions at the cost of image accuracy.

"Perspective"

This control is used to toggle perspective viewing on and off. Perspective viewing offers the user a more realistic appearance to the model, however, many of the editing features in MD cannot be used. The *"Find Scene"* option should be used after changing the perspective option because the location of the viewer is usually at a confusing location.

"Layout"

This control is used to change the current layout. The available choices are: *"quad"*, *"3 and 1"* or *"1 and 1"*.

"Orient"

Use this control to move the eye position and change the rotations in an orderly way. There are several choices available:

- *"to XY Plane"* The user is prompted for the new eye position and the view is then rotated so as to properly view the X and Y axes.
- *"to YZ Plane"* The user is prompted for the new eye position and the view is then rotated so as to properly view the Y and Z axes.
- *"to XZ Plane"* The user is prompted for the new eye position and the view is then rotated so as to properly view the X and Z axes.
- *"to 3 Points"* The user is prompted for 3 points that define a plane. The eye position is set to the first point and the view is rotated to point into the plane.
- *"to a plate"* The user is prompted to click on any flat plate in any of the views. The eye position is then set to one of the corners of the plate and the view is rotated to point into the plate. Unwanted affects may occur if the selected plate is not flat.

"Thickness"

This control is used to change the thickness of the view. There are three choices available:

- *"zero"* Produce a cross-section of the model through the current eye position.

- *"define..."* The user is prompted for the required thickness producing a slice of the model centered at the current eye position.

- *"infinite"* Remove the effects of thickness.

"Grid"

This control is used to change the properties of the view's grid. There are three choices available:

- *"off"* Turn the grid off.

- *"Auto"* The view produces a grid with appropriate spacing and labels. This is the default.

- *"define..."* The user is prompted for the spacing of the grid. Labels are placed on the grid lines at appropriate locations.

"Print"

This control allows the user to print the contents of the view.

On a Sun workstation, this option produces a sun pixrect image file. The user is prompted for the filename of the image file. The size of the image is determined from the *"Setup"* menu.

On an PC, this option allows the user to print an image of the current view on any MS-Windows compatible printer. The user is able to choose the printer from a Dialogue box. MD uses the "Slow/Fast" status to determine how to print the view.

- *"Slow"* MD creates a bitmap that is then sent to the printer. The *"Setup"* menus print dimensions are used to determine the size of the bitmap. The interpretation of these fields is as follows:

blank or 0:	scale bitmap to approx. 100dpi (default)
positive value:	use value for dimension of bitmap
negative value:	scale bitmap 1 pixel= (-n)printer pixels

- *"Fast"* MD "draws" the image to the printer. The *"Setup"* menu print dimesions are used to determine the size of the font that would match the *"Slow"* printout.

"Copy"

Not available on a Sun workstation.

This control allows the user to copy the image in the view to the clipboard. MD uses the "Slow/Fast" status to determine what to place in the clipboard:

- *"Slow"* MD creates a bitmap that is placed in the clipboard. The *"Setup"* menus print dimensions are used to determine the size of the bitmap. The interpretation of these fields is as follows:

blank or < 10:	use 500 pixels	(default)
positive value:	use value for dimension of bitmap	

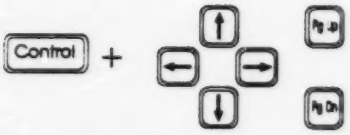
- *"Fast"* MD creates a Windows M[illegible]file and places it in the clipboard. The *"Setup"* menu print dimesions are [illegible]ed to determine the size of the font that would match the *"Slow"* printout.

3.2.2 Keyboard Controls

Several keyboard controls have been included to provide interactive movement and orientation. They are:

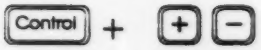
Rotate view by the rotation increment

Scale the rotation increment by 2 or $\frac{1}{2}$ respectively (Default 10°).



Move eye position relative to current orientation by the movement increment.

Note: Up and Down arrows move the eye position forward and backwards while the PgUp and PgDn keys move vertically.



Scale movement increment by 2 or $\frac{1}{2}$ respectively (Default 1 unit).

3.3 Coordinate Entry

Inputting the coordinates for 3-dimensional points is an integral part of MD. To keep the interface consistent, all coordinates are entered using this same procedure. During point entry, the view response area takes the following form:

Figure 8 - View response area during point entry

Keyboard entry

To enter the coordinates using the keyboard, simply change the values in the x, y and z fields of the view response area and press the *"Set"* button.

Mouse entry

During coordinate entry a pointer symbol will appear in each view showing the current location. These symbols can be moved according to the current selection mode by simply dragging the mouse with the left mouse button in any of the views. The x, y, and z values in the view response area will automatically be updated. To accept the location, press the *"Set"* button or click the left mouse button. The *"Cancel"* button is used to cancel the operation.

3.3.1 Point Selection Modes

The current selection mode can be changed using the *"Mode"* item in the view response area. The four available modes are:

- *"XYZ"* (Default) Simply move the pointer in any of the views. The pointer is always moved parallel to the view's orientation.
- *"On pt"* Click on any point or vertex in a view to move the pointer to that location.
- *"Mid"* Click on any line or plate edge to move the pointer to the midpoint of the segment.
- *"Along"* Click and drag the pointer along a line or plate edge.

3.3.2 Measuring Tape

A measuring tape feature is provided to measure the distance from the current location to a secondary location. A pointer symbol appears in each view to indicate the secondary location. The *"Tape"* check box turns this feature on and off. The *"Dist"* field specifies the current distance. The *"Set Tape"* button copies the current location into the secondary location.

3.3.3 Snapping

The coordinates generated by moving the mouse may be cleaned up (removing insignificant figures) by changing the *"Snap"* value. The x, y and z values are rounded to the nearest increment of the *"Snap"* value. For example, the number 121.3484 would be rounded to 121.4 if the *"Snap"* value was 0.2.

4. DRILL HOLES

Drill holes are considered to be more or less drawing aids within MD. They can be imported and viewed to help define other mine elements such as ore body outlines. The representation of a drill hole is reasonably simple: a series of two-coloured lines with a text label at the starting point. The lines are colour coded red and black to indicate segments above and below a given grade.

4.1 Importing Drill Holes

Drill hole data is imported from text data files. The format for these files can be found in section 11.1.1. Drill hole data can be imported to replace or add to MDs existing data. The *"Geom, Holes, Import"* menu is shown below:

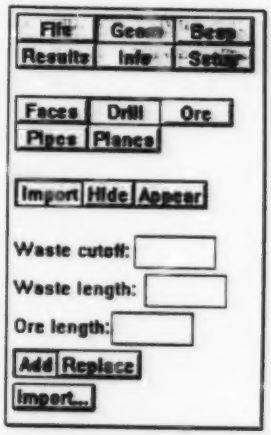


Figure 9 - The "Holes, Import" Menu

A compression scheme is provided to enhance MD's performance and memory requirements. As a drawing aid, drill hole data points can be spread far apart in waste areas and more closely spaced in areas of interest (ore). To accommodate this scheme, three user defined values must be determined: the waste cutoff grade, the best length of waste segments, and the best length of ore segments. Knowing these values, MD will combine any segments that when combined will still be shorter than the best length for ore and waste areas. The grades for combined segments are calculated by a weighted average. Depending on the accuracy of the original file data, the results of the compression can dramatically affect the performance of MD.

4.2 Drill Hole Appearance

The Drill Hole Appearance menu provides a means of selecting the grade type and cutoff displayed in the colour-coding of the drill holes. The grade type is simply a value between 1 and 4. The cutoff defines which segments of the drill holes will be coloured red and which will be coloured black. The *"Geom, Holes, Appear"* menu is shown below:

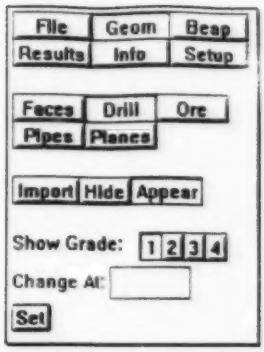


Figure 10 - The *"Geom,Holes, Appear"* menu

To change the appearance of the drill holes simply set the *"Show Grade"* and *"Grade Cutoff"* to the required values and press *"Set"*. All segments having a grade of the selected type greater than the cutoff value will be drawn in red and all others in black.

5. ORE BODY DEFINITION

An ore body is represented by a collection of surface patches that define the transition from minable to unwanted ore. These surface patches are created by an automatic mesh generator built into MD. The mesh generator creates the surface by "sweeping" one or more sets of edges. The edges provided to the generator can be imported from text files or input directly. The edges can be edited and broken down into smaller edges.

A set of edges consists of one or more touching edges that can be connected end to end to construct one path. If the resulting start and end points touch, the set of edges is said to be closed.

There are effectively two different types of surface patches: caps and sides. A cap surface is constructed when only one closed set of edges is provided. Side surfaces are constructed when two sets of either open or closed edges are provided. Figure 11 illustrate the different types of patches.

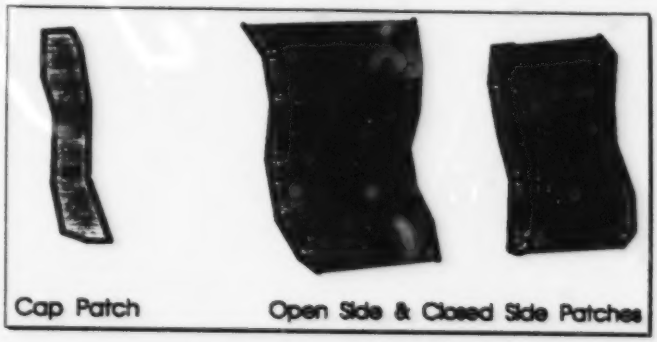


Figure 11 - The different types of Ore Body Patches

Cap patches are drawn as a solid polygon while side patches are made up of multiple triangles. When creating side patches, the mesh generator must match the points on one edge set with those of the other. The second set of edges is automatically reversed if the generator determines that the ordering of the points is in the opposite direction. The matching of the points can be customized by the user to handle special circumstances by introducing a shape coefficient that determines the preference of the generator between shape and point proximity. For example, figure 12 illustrate two different patches that can result from the same edge sets.

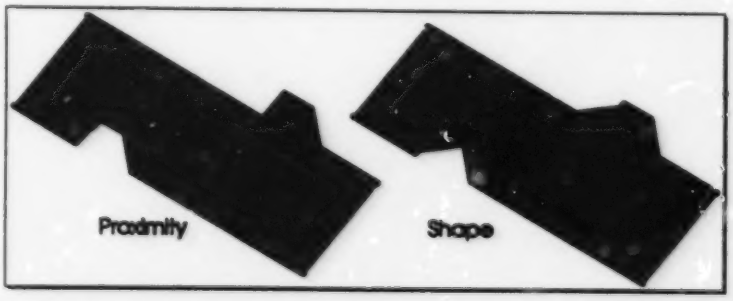


Figure 12 - Example of different shape coefficients

A more detailed description of ore body editing can be found in the following sections.

The mesh generator assumes that the shape of the edge sets for side patches will be *reasonably* similar in overall shape. If two edge sets produce a patch that is not acceptable, the patch may have to be broken down into smaller patches. This can be accomplished in several ways. One method would be to break the edge sets into more manageable pieces. Another method would be to introducing an intermediate edge set between the existing ones.

There are often severe cases of shape dissimilarity that require some ingenuity. An example is provided in section 12.1 to illustrate some of the considerations and planning that are required for modelling real ore bodies.

5.1 Importing Ore Body Cross-sections

Ore body edges can be digitized outside of MB and then imported. The file format can be found in section 11.1.2. To import an edge file, set the menu to *"Geom, Ore, Import"*, enter the filename in the space provided and then press "Import". The edges in the file are added to the existing edges.

5.2 Editing Ore Bodies

The editing of ore body edges and patches is handled separately. The following sections describe each type of editing.

5.2.1 Ore body Edges

To begin edge editing, set the menu to *"Geom, Ore, Edit, Edges"*. While in this menu, the edge currently being edited will be highlighted in red. Small boxes will show the location of the points along the edge. To allow for mistakes, any changes to an edge are not recorded unless the *"Set"* button is pressed (except where noted). To ignore any changes simply select another edge or leave the *"Geom, Ore, Edit, Edges"* menu.

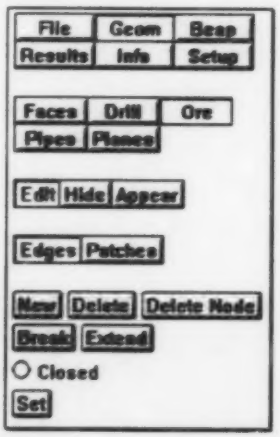


Figure 13 - The *"Geom, Ore, Edit, Edges"* menu

Procedures

- *to add a new edge* - press the *"Add"* button
  - enter all of the points on the edge
  - to finish, enter the same point as the last or Press the *"Cancel"* button.
- *to select an edge* - simply click anywhere on the edge in a view if it is not already selected
- *to delete an edge* - select the edge and then press the *"Delete"* Button
- *to select an edge point* - select the edge and then click in the box highlighting the point (the highlighted box will be larger)
- *to move an edge point* - select the edge point, click on the point again
  - enter the location of the new point
- *to insert an edge point* - select the edge and then click on the segment of the edge that is to be divided by the new point
  - enter the location of the new point
- *to append an edge point* - select the edge point at the end of the edge
  - press the *"Extend"* button
  - enter the location of the new point
- *to delete an edge point* - select the edge point and then press the *"Delete Node"* button
- *to break an edge* - select the edge point where the break is to occur and then press the *"Break"* button. If the edge was closed, it will be opened at that point. If the edge was open, the edge will be broken into two new edges. (Note: the current changes to the original edge will be recorded prior to the break).
- *to open or close an edge* - select the edge and then set the *"Closed"* checkbox to the required setting
- *to record edge changes* - press the *"Set"* button
- *to ignore an edge changes* - press the *"Edges"* menu item or select a different edge

5.2.2 Ore body Patches

To begin patch editing, set the menu to *"Geom, Ore, Edit, Patches"*. While in this menu, the patch currently being edited will be highlighted in red and blue. Since a patch is generated from one or two sets of edges the red and blue highlighting differentiates between the two sets. To

allow for mistakes, any changes to a patch are not recorded until the *"Set"* button is pressed. To ignore any changes simply press the centre mouse button while in one of the views or leave the *"Geom, Ore, Edit, Patches"* menu.

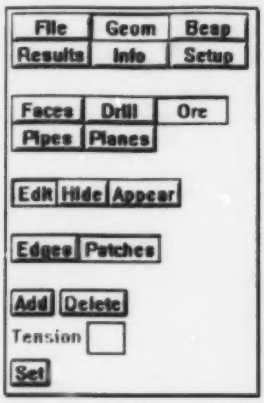


Figure 14 - The *"Geom, Ore, Edit, Patches" menu*

Procedures

- *to add/remove an edge from a patch*
  - click on the edge to cycle its status from "in edge set 1" (red), to "in edge set 2" (blue) to "in neither" (black). The colour of the edge changes to show its status.
- *to select a patch* - click on a part of the patch in any of the views
- *to add a new patch* - press the *"Add"* button
  - add the required edges
- *to delete a patch* - select the patch and then press the *"Delete"* button
- *to change the shape coefficient of a patch*
  - change the *"Tension"* value. Positive values favor proximity while negative values favor shape. The default is zero (or blank). Typical values range from -100 to 100.
- *to record any changes to a patch*
  - press the *"Set"* button
- *to ignore any changes to a patch*
  - press the *"Patches"* menu item.

6. PLANES

A plane is a flat rectangular surface of a given width, height, centre point and orientation. The orientation of the plane is defined from one of six different methods describe later.

Planes are provided for several purposes. They are very useful as 3-dimensional construction aides for marking out such things as pillar locations in 3-D and cross-sectional views. They are useful as orientation tools because planes can be added for each mining level and then used to reorient views (see section 3.2.1 regarding *"Orient"*, *"to a plate"*).

6.1 Editing Planes

To begin plane editing, set the menu to *"Geom, Planes, Edit"*. While in this menu, the plane currently being edited will be highlighted in red and the edit fields in the menu will show the current parameters defining the plane. To allow for mistakes, any changes to a plane are not recorded until the *"Set"* button is pressed. To ignore any changes simply select a different plane in one of the views or leave the *"Geom, Planes, Edit"* menu.

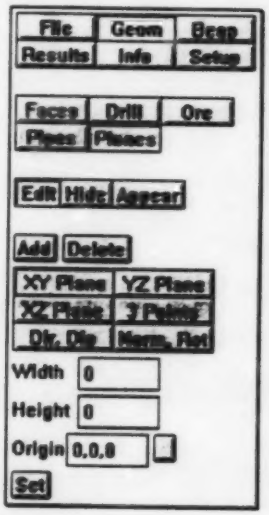


Figure 15 - *"Geom, Planes, Edit"* menu

All planes have *"Width"*, *"Height"* and *"Origin"* (centre point) parameters. Three of the six orientation types have additional parameters. A detailed description of the six orientation types follows:

- ***"XY Plane"*** A plane oriented parallel to the X and Y axes.
- ***"YZ Plane"*** A plane oriented parallel to the Y and Z axes.
- ***"XZ Plane"*** A plane oriented parallel to the X and Z axes.
- ***"3 Points"*** A plane oriented by three points. Two additional fields define the other points: *"2nd Pt"* and *"3rd Pt"*.

- ***"Dir, Dip"*** A plane oriented by two angles. The *"Direction"* field specifies the z-rotation or bearing. The *"Dip"* field specifies the dip of the plane from the horizontal.
- ***"Norm, Rot"*** A plane oriented by a normal and a twisting rotation. The *"Normal"* field specifies a vector (X,Y,Z) defining the plane's normal. The *"Rotate"* field defines the twist of the plane.

Note: When orienting a view to a *"Norm, Rot"* plane, the *"Rotate"* field is ignored.

Procedures

- *to add a plane* - press the *"Add"* button. The edit fields are left as they were when the last plane was edited. This allows the user to duplicate planes and then change only the parameters that differ.
- *to select a plane* - click on the plane in one of the views. The plane will be highlighted in red.
- *to delete a plane* - select the plane and then press the *"Delete"* button.
- *to edit a plane* - select the plane and then change the fields that require editing.
- *to record changes* - press the *"Set"* button.
- *to ignore changes* - select another plane or press the *"Edit"* menu item.

7. PIPING DEFINITION

The name piping refers to the all drifts, shafts and raises, etc. MD includes the definition of piping to allow for better visualization of the model. MD's representation of piping is simple to insure that it is an easy tool.

A pipe is defined to be a series of points with varying width, height and rotation parameters. The representation of the pipe is generated by "sweeping" a rectangular cross-section along the centre line specified by the series of points. The size, shape and orientation of the cross-section varies along the centre line according to the parameters provided at each point.

A pipe can be created, edited, broken into smaller pipes and deleted. As with all other objects in MD, the appearance and visibility of pipes can also be changed.

7.1 Editing Piping

To begin pipe editing, set the menu to *"Geom, Pipes, Edit"*. While in this menu, the pipe currently being edited will have its centre line highlighted in red. The points on the centre line will be drawn as small boxes. The point on the centre line currently being edited will be highlighted with a larger box. The edit fields in the menu will indicate the parameters for that point. To allow for mistakes, any changes to a pipe are not recorded until the *"Set"* button is pressed. To ignore any changes simply select a different pipe in one of the views or leave the *"Geom, Pipes, Edit"* menu.

Procedures

- *to add a new pipe* - press the *"Add"* button
  - enter all of the points on the pipe
  - to finish, enter the same point as the last or press the *"Cancel"* button.
- *to select a pipe* - simply click anywhere on the pipe in a view if it is not already selected
- *to delete a pipe* - select the pipe and then press the *"Delete"* Button
- *to select a point* - select the pipe and then click in the box highlighting the point (the highlighted box will be larger)
- *to move a point* - select the centre line point and then click on the point again
  - enter the location of the new point
- *to change the parameters for a point*
  - select the centre line point.
  - change the required parameters
- *to insert a point* - select the pipe and then click on the segment of the centre line that is to be divided by the new point
  - enter the location of the new point

- *to append a point* - select the centre line point at the correct end of the pipe
  - press the *"Extend"* button
  - enter the location of the new point
- *to delete a point* - select the centre line point and then press the *"Delete Node"* button
- *to break a pipe* - select the centre line point where the break is to occur and then press the *"Break"* button. The edge will be broken into two new edges. (Note: the current changes to the original pipe will be recorded prior to the break).
- *to record pipe changes* - press the *"Set"* button
- *to ignore any changes* - press the *"Edit"* menu item or select a different pipe

8. STOPE FACE DEFINITION

Stopes are constructed from faces in MD. A face can be a triangle, a linear quadrilateral or a quadratic quadrilateral depending on the number of nodes that define it. The faces are subdivided into elements according to the properties of the face.

The user has full control over the definition of the stope faces. The user is responsible for defining all of the nodes (points) used by the faces and the construction of the faces. The additional nodes created by the subdivision of the faces are maintained by MD. The faces must be defined in a consistant order. When a face is viewed from within the rock the nodes must be ordered in a clockwise direction. Faces ordered in the opposite direction will be painted solid grey while those ordered correctly will be coloured according to the defined "appearance" for stope faces.

Stope faces have several properties associated with them to describe their geometry and characteristics. These properties are:

"Name"	- a name used for identification
"Subdivide"	- element subdivisioning
Nodes	- the nodes defining the geometry of the face
"Material"	- the material (subregion) type
"Loading"	- special loading

For more information about the *"Material" and "Loading"* properties of an element please refer to the BEAP USER MANUAL.

As described above, a face can be formed from several shapes depending on the number of nodes that define it. Figure 16 illustrates the different types of faces and the ordering of the nodes.

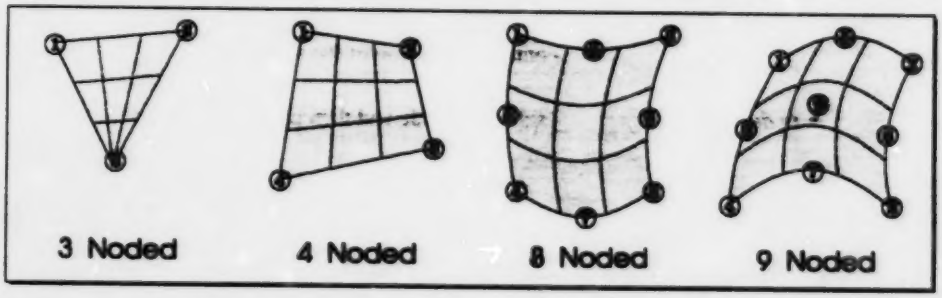


Figure 16 - The different types of faces.

8.1 Editing Stopes

8.1.1 Editing Nodes

Nodes define the shape and location of the stope faces. Nodes are simply 3-dimensional points shown as circles. Nodes can be added, moved and deleted.

To begin node editing, change the menu to *"Geom, Faces, Edit, Nodes"*. The node currently being edited is identified by a solid red circle while all other nodes are drawn as hollow black circles.

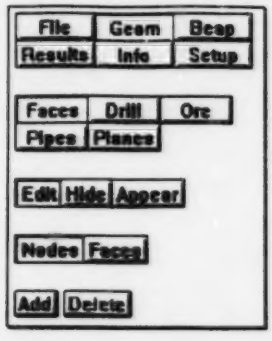


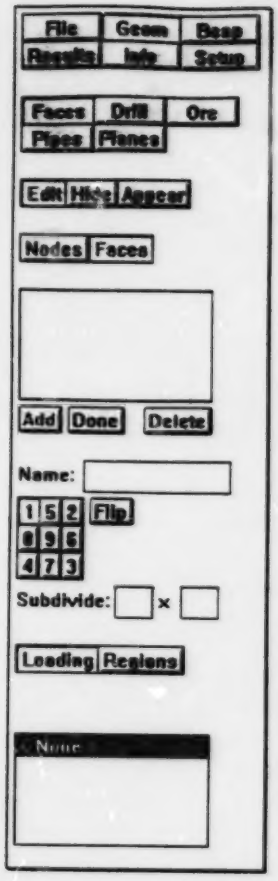
Figure 17 - *"Geom, Faces, Edit, Nodes"* menu

Procedures

- *to add new nodes* - press the *"Add"* button
  - enter the location of the nodes
  - enter the same location twice or press "Cancel" when done
- *to select a node* - simply click on the node in a view if it is not already selected
- *to move a node* - select the node to moved
  - click on the node again
  - enter the location of the node
- *to delete a node* - select the node and then press the *"Delete"* button

8.1.2 Editing Faces

To begin face editing, set the menu to *"Geom, Faces, Edit, Faces"*. While in this menu, the face currently being edited will be highlighted in red. The edit fields in will indicate the parameters for that face.



There are some editing fields in the menu that require some special discussion.

A list of the faces by name is provided to allow the user to select a face by name. The list is sorted in the order that the faces were created.

A 3x3 grid of buttons or node pad is provided in the menu to symbolize the nodes defining a face. The node pad provides a means of identifying and entering the series of nodes.

Figure 18 - *"Geom, Faces, Edit, Faces"* menu.

Procedures

- *to add a new face* - press the *"Add"* button
  - make all necessary changes to the face
- *to select an face* - simply click anywhere on the face in a view if it is not already selected or click on the name of the face in the list of face names
- *to delete a face* - select the face
  - press the *"Delete"* button
- *to change the properties of a face*
  - select the face
  - press the *"Modify"* button
  - change the required properties in the menu
- *to view the nodes* - press the *"Modify"* button

- press the node pad button corresponding to the node in question. The node will be highlighted in the views.

- *to define all nodes*
  - press the *"1"* button on the node pad.
  - click on the first node in one of the views. The node pad will then show the next node to be entered
  - click on the next node in one of the views
  - continue until all nodes are entered

- *to change the nodes*
  - press the *"Modify"* button
  - press the node pad button corresponding to the node that is to be changed
  - click on the new node in one of the views. The node pad will change to the next button

- *to remove a node*
  - press the *"Modify"* button
  - press on the node pad button corresponding to the node that is to be removed
  - press on the node pad button again

- *to reverse the order of the nodes*
  - press the *"Modify"* button
  - press the *"Flip"* button

- *to record face changes*
  - press the *"Done"* button
  - Note: selecting a new face in the list or pressing *"Add"* automatically saves any changes being made to the current face

9. BEAP3D ANALYSIS

MD has a built in interface to the BEAP3D analysis package. The user has the ability to access all of the necessary variables required to describe a BEAP3D model as well as the ability to initiate and monitor the BEAP3D solving processes. The following section describes the interface and its usage.

To allow the user the flexibility of running the solver in and out of the windowing environment, MD prepares and uses the same files as the command line version of BEAP3D. This allows the user the option of "batching" the solver at the DOS level and still access the pre and post processing capabilities of MD.

! This section describes the interface to the BEAP3D functionality provided in MD. This section does not describe how to properly use BEAP3D. The user must read the BEAP3D USER MANUAL to fully understand how to use BEAP3D because failure to do so would result in a useless model.

9.1 File layout

The files required for a BEAP3D analysis have fixed names. This causes problem when solving multiple models in the same directory. To remedy this problem, a strict directory structure is required to guarantee that MD and BEAP3D peacefully coexist.

The naming for MD data files consists of adding a .DES extension to the end of the filename. Any number of MD data files may exist in a directory. When MD starts a BEAP3D solution, it creates a directory having the same name as the data file with a .RES extension. For the time being, all of the BEAP3D data files will be located in this new subdirectory.

The following files are created by MD in the .RES subdirectory:

- beap.fil - a file describing the names of the geometry files
- geom.1 - Global Nodes and Elements Definitions
- geom.2 - Element Code and Subregion Definitions
- prop.3 - Remaining Input Data

All of the properties accessible from within MD are saved within the MD data file. All of the files within the .RES directory are generated by running MD and BEAP3D and are therefore redundant. When the results of a model are no longer needed it is advisable to delete the .RES directory and its contents entirely. The results can of course be regenerated by loading the MD data file and solving again.

9.2 General Properties

A brief description of the properties is provided below. The user should refer to the BEAP USER MANUAL for more detailed descriptions.

The general beap properties can be viewed and modified from the *"Beap, Config"* menu. The heading used by BEAP3D for its output can be changed there. The remaining properties are grouped into three sub menus: *"ITERAT"*, *"PRIM"* and *"INTEGR"*. Where possible, the labels used in MD duplicate those in the BEAP USER MANUAL and appropriate default values for the available properties are provided.

9.2.1 Iteration Parameters

Parameter	Description	Default Value
NITER	Maximum iterations	20
OMEGA	Relaxation factor	0.8
DEL	Convergence ratio	0.0001
NITSUB	Number of Sub-iterations	1
ACCEL	Acceleration factor	1

9.2.2 Primitive Stresses

The total primitive stresses are defined as a linear relationship with depth as the independent variable. It consists of a consant value and a component which is depth dependant. To modify the primitive stress coefficients, the user must select the appropriate definition to be modified (e.g. XX-Stress) and then modify the two fields below. The first field is the constant value and the second field is the depth dependant component of the primitive stresses.

The BEAP USER MANUAL allows the user to modify all nine coefficients. The three shear values are duplicated because of symmetry. MD duplicates these values for the user when transferring the information to the third file thus MD only shows six.

9.2.3 Integration Parameters

Parameter	Default Value
TR2	6.0
TR3	3.0
TR4	1.8
TR5	1.0
TR6	0.5
TR10	0.3
TRLB	0.7
SSW6	2.0

9.3 Element Properties

The remaining BEAP3D properties are associated with elements. The user must define these properties and then attach the definitions to the appropriate elements.

The *"Beap, Loading"* and *"Beap, Regions"* menus allow the user to define the loading and material properties that will be attached to the elements. The user should create these definitions before creating the geometry because it is easier to attach the properties when creating the geometry rather than after.

The properties are referenced by name. This name can be anything that makes sense to the user. The names are not transferred to BEAP3D but are replaced by automatically generated numbers appropriate for the BEAP3D file formats.

Once these property definitions are created they can be attached to elements. This is done from the *"Geom, Faces, Edit, Faces"* menu. While editing a face, the user may select the appropriate definition from a list. If the user does not select a definition, an appropriate default is given.

9.3.1 Material Properties

A material (subregion) consists of these properties:

- *"Name"*
- *"Young's Modulus"*
- *"Poissons's Ratio"*
- *"Symmetry"*

Refer to the SUBS keyword in the BEAP USER MANUAL for more information.

9.3.2 Loading Properties

A load definition consists of the following properties:

- *"Name"*
- Type (*"Normal"*, *"Fixed"*, *"Fixed-X"*, *"Fixed-Y"*, *"Fixed-Z"* or *"Interface"*)
- *"Tractions"* (if Type is *"Normal"*)
- *"Interface to:"* (if Type is *"Interface"*)

Refer to the SPTRAC and BOUNDR keywords and the FILE.2 description in the BEAP USER MANUAL for more information.

If the Type field is set to *"Normal"*, tractions may be applied to the element. A 3x3 button pad is provided to allow the user to select individual function nodes and an edit field to enter the traction (tx,ty,yz).

If the Type field is set to *"Interface"*, a list of the available material types becomes available.

9.4 Executing Analysis Modules

Once a model has been properly defined it may be solved. The solver can be run directly from MD or from within the operating system. The choice depends on the needs of the user.

On Sun workstations, there is no time benefit to running the solver from the operating system. The program runs at the same speed regardless of how it is run. The drawback to running BEAP3D from within MD is that MD must be active for the duration of the run. If the model is relatively small or the workstation is dedicated to the model, MD is the obvious choice because of its ease of use. If the model is relatively large and will take too long for the workstation to be tied up, the user should run BEAP3D from the command prompt.

On PC workstations, the time required to run a model from within MD is approximately 10% longer than running BEAP3D from MS-DOS. Running BEAP3D from MS-DOS may be more tedious but may save time. Running BEAP3D from MS-DOS also has a drawback, without the multitasking abilities of MS-Windows, the computer is tied up solving the model for the duration of the run.

To run BEAP3D from within the operation system refer to the BEAP USER MANUAL. The remaining part of this section describes how to run BEAP3D from within MD.

The following table describes the BEAP3D modules used from within MD and the phases at which they are run (C = Checking S = Solving R = Results):

Module	Description	C	S	R
M101	Initialize the database	√	√	
M201	Read in node and element geometry	√	√	

M203	Read in element TYPE definitions and check	√	√	
M401	Read in other input data	√	√	
M501	Apply tractions due to primitive stress		√	
M502	Calculate lumping maps		√	
M503	Calculate influence coefficients		√	
M504	Solve equations		√	
M205D	Get element results			√
M507D	Calculate Benchmarks			√

The user is always given the ability to abort the execution of the various BEAP3D components usually in the form of a Stop or Cancel button. The MD menus are made inactive while BEAP3D is executing to prevent MD from becoming unstable. The user can however change MD into an icon and continue using the windowing system with BEAP3D executing in the background.

9.4.1 Checking a Model

Checking a model consists of writing out the BEAP3D data files and executing the initial set of BEAP3D modules. The initial set of modules (see table above) are not time consuming and can therefore be run during an interactive session to determine the state of the model. Any geometric errors will be reported during this phase.

9.4.2 Solving a Model

Solving a model performs all of the modules described above. Solving is extremely time consuming, it can take hours and even days depending on the size of your model. It is therefore important to prepare for the solution by clearing out any unnecessary files from the hard disk and in the case of the Sun version, make sure that there are no other big jobs running on the workstation.

9.4.3 Geometric Errors

While BEAP3D is executing, MD collects any errors or warnings that are generated. These warnings can then be reviewed by the user.

10. VIEWING RESULTS

10.1 Introduction

The results available from the analysis of a 3-D model are usually too difficult to evaluate from the typical printouts that are generated by the analyis package. MD has been equiped with post-processing capabilities to simplify and enhance the presentation of these results.

MD is capable of representing two types of results: surface and interior results. The surface results are found on the geometric elements themselves. The interior results are results determined at arbitrary points within the rock mass.

When the menu is set to *"Results, ..."* the views display any of the geometry* that was visible in the *"Geom, ..."* menu as well as any results that are visible.

10.2 Legend Control

The legend is controlled from within the *"Results, Legend"* menu. The type of stress, scale limits, and displacement factor are set in this menu.

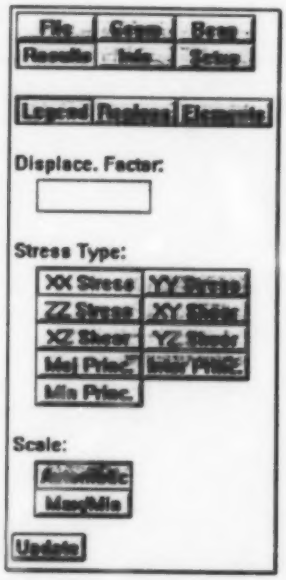


Figure 19 - The *"Results, Legend"* menu

- *"Stress Type"*

  This control specifies the type of stress that will be displayed. The available stress types are: σ_{xx}, σ_{yy}, σ_{zz}, τ_{xy}, τ_{xz}, τ_{yz}, σ_1, σ_2, σ_3, and several failure criteria.

* except Faces when *"Results, Elements, Appear, Show original"* is not selected.

- ***"Scale"* Limits**

  The user can choose an automatic scale, or a manual one. The limits of an automatic scale are determined by MD by searching through the visible results and determining the maximum and minimum values. For a manual scale, the user is prompted for the maximum and minimum values.

- ***"Displacement Factor"***

  When displacements are available, this factor is applied to the displacements to make them more apparent. Leaving the field blank, sets the value to zero thus removing the effect of the displacement.

Once the appropriate changes have been made to the legend controls, the *"Set"* button must be pressed to update the views.

10.3 Element Results

Element results are the simplest results to display. Each element of the model is represented by a grid that can show element results. The element results features can be accessed from the *"Results, Elements"* menu.

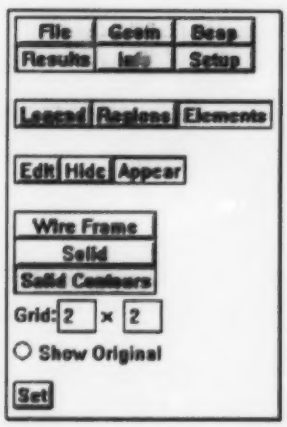


Figure 20 - The *"Results, Elements, Appear"* menu

All of the element results are calculated at one time by pressing the *"Results, Elements, Edit, Update"* button (Note: it may take a while). The results can be discarded by pressing the *"Results, Elements, Edit, Purge"* button.

10.3.1 Appearance

The appearance of the element results is controlled by the *"Results, Elements, Appear."* menu. The user has control of the following:

- ***"Wire Frame"*, *"Solid"* or *"Solid Contours"***

  This control allows the user to change the appearance of the grid.

- *"Grid"*

  These controls allows the user to specify the grid density of the elements. The density is entered as pair of integer values. Usually the two values should be the same but in some cases more control is benificial.

- *"Show Original"*

  This control allows the user to superimpose the original geometry with the displaced grid, or show the presence of the faces if no element results are visible or available.

10.4 Result Regions

A "result region" is a set of results that describe a region of the model. These regions can be linear, planar or spacial. The result region features can be accessed from the *"Results, Regions"* menu.

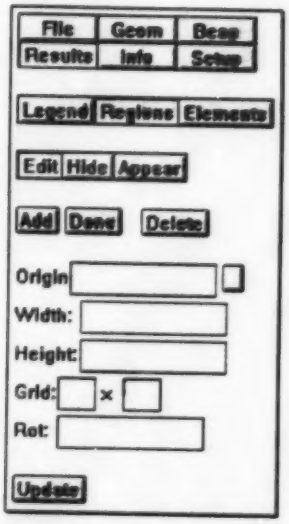


Figure 21 - The *"Results, Regions, Edit"* menu

To add or modify a region, select the *"Results, Regions, Edit"* menu. Press the *"Add"* button to create a new region or select the region with the mouse and press the *"Modify"* button to edit an existing region. Once a region is selected, it can be deleted by pressing the *"Delete"* menu.

The region is drawn as a gray grid when the region requires updating. Updating a region causes MD to envoke the analysis and request the results for the various points that make up the region. If the region is modified (e.g. moved), the results are discarded. Pressing the *"Update"* button updates the region. When a region has been updated, it is drawn using black lines or coloured faces depending on the current "appearance" selected in the *"Results, Regions, Appear"* menu.

The result regions are stored in the MD data file (.DES). The user can delete the .RES directory or rename the data file and still keep the result planes intact.

10.4.1 Linear Regions

Not yet implemented

10.4.2 Planar Regions

A planar region consists of a regularly spaced set of points on a plane. The plane can be arbitrarly oriented and sized. The spacing of the points can also be set. When editing a planar region, the following parameters can be changed:

- *"Origin"*

  The user may enter the coordinates of the center of the plane or press the adjacent button to graphical enter the point.

- *"Width", "Height"*

  The width and height of the plane.

- *"Grid"*

  The grid spacing is entered as an integer pair. Acceptable values range from 1 to 20.

- *"Rot"*

  The rotation of the plane. The rotation is entered as three rotation: R_x, R_y and R_z separated by commas. R_x is the rotation in degrees about the x-axis.

10.4.3 Spacial Regions

Not yet implemented

11. TECHNICAL DESCRIPTIONS

11.1 Data File Formats

11.1.1 Drill Hole Data

This data file provides the descriptions for any number of drill holes. Each drill hole consists of a series of points and up to 4 grades describing the segment that follows.

n	name					
x_1	y_1	z_1	g_{11}	[g_{12}	[g_{13}	[g_{14}]]]
x_2	y_2	z_2	g_{21}	[g_{22}	[g_{23}	[g_{24}]]]
.						
.						
.						
x_{n-1}	y_{n-1}	z_{n-1}	g_{n-11}	[g_{n-12}	[g_{n-13}	[g_{n-14}]]]
x_n	y_n	z_n				
n	name					
.						
.						
.						

where:
- n ..... number of points along the drill hole
- name ..... text label for drill hole
- x_i y_i z_i ..... coordinates for i^{th} point along the drill hole
- g_{ij} ..... j^{th} grade for the segment between the i^{th} and $i+1^{th}$ points along the drill hole. Note: [] denote optional.

11.1.2 Mine Designer Data (.DES)

The MD data file is an unformatted text file. The file is separated into sections corresponding to the different sections of MD. Each section begins with a section heading. A section heading is a single word label beginning with a colon (:). Unless otherwise noted, sections are optional and may be in any order.

The following table describes the format of the MD data files. The description, format and required fields are provided.

VERSION	**Desc.**	Version number of MD that created the file. This section must exist and should be the first section in the file.	
	Format	:VERSION *version*	
	Fields	*version*	The version number is specified in hexidecimal. (e.g. 0x130 specifies version 1.30)

ANALYSIS

Desc. This section contains the data specific to the analysis packages. This section must precede the STOPEFACES section. Multiple analysis packages can be used for the same model. Each analysis package that was available at the time of saving generates a sub section.

Format
:ANALYSIS
<package-name>
package specific data...
<package-name>
...

MENUS

Desc. This section contains information related to the state of the menus at the time of saving.

Format
:MENUS
internal format...

_DRILL_HOLES

Desc. This section contains the compressed drill hole data information

Format
:_DRILL_HOLES
internal format...

OREEDGES

Desc. This section contains ore edge data. Each edge has a unique id that is used in the OREPATCHES section.

Format
:OREEDGES
!id n
$x_1\ y_1\ z_1$
...
$x_n\ y_n\ z_n$
<repeat>

Fields

!	optional, if present edge is hidden
id	identification number (1-32767)
n	number of nodes
$x_i\ y_i\ z_i$	location of node i

OREPATCHES

Desc. This section contains ore patch data. The OREEDGES section must precede this section.

Format
:OREPATCHES
!n $id_{11}\ id_{12} \ldots id_{1n}$ *m* $id_{21}\ id_{22} \ldots id_{2m}$ *factor*
<repeat>

Fields

!	optional, if present patch is hidden
n	number of edges on side 1
m	number of edges on side 2
id_{ij}	j^{th} edge id for side i
factor	patch tension factor

STOPENODES

Desc. This section contains stope node data.

Format

:STOPENODES
!id x y z
<repeat>

Fields

!	optional, if present node is hidden
id	id of node (1-32767)
x y z	location of node

STOPEFACES

Desc. This section contains stope face data. The STOPENODES must precede this section.

Format

:STOPEFACES
! "name" n id1 ... idn subr subv properties...
<repeat>

Fields

!	optional, if present face is hidden
name	name for identification (in double quotes)
n	number of nodes (3,4,8 or 9)
id_i	ids of nodes
sub_r sub_v	element subdivisioning
propeties...	face properties. If the ANALYSIS section and the <Beap n.nn> subsection are present, the loading id and material id must follow. Otherwise the properties... field is blank..

PIPES

Desc. This section contains pipe data.

Format

:PIPES
!n
x_1 y_1 z_1 w_1 h_1 r_1
...
x_n y_n z_n
<repeat>

Fields

!	optional, if present edge is hidden
n	number of nodes
x_i y_i z_i	location of node i
w_i	width at node i
h_i	height at node i
r_i	rotation at node i

PLANES

Desc. This section contains plane data.

Format

:PLANES
!type width height o_x o_y o_z *extra...*
<repeat>

if *type* = 3
  extra... = $pt2_x$ $pt2_y$ $pt2_z$ $pt3_x$ $pt3_y$ $pt3_z$
if *type* = 4
  extra... = *direction dip*
if *type* = 5
  extra... = n_x n_y n_z *rotation*

Fields

!	optional, if present plane is hidden	
type	type of plane:	
	0	XY plane
	1	YZ plane
	2	XZ plane
	3	3 point
	4	dir, dip
	5	norm, rot
width height	size of plane	
o_x o_y o_z	location of the center of the plane	
$pt2_x$ $pt2_y$ $pt2_z$	location of 2nd point	
$pt3_x$ $pt3_y$ $pt3_z$	location of 3rd point	
direction	direction (North = 0) in degrees	
dip	dip in degrees	
n_x n_y n_z	normal	
rotation	rotation of plane in degrees	

RESULTS

Desc. This section contains the legend, elements and region results.

Format

:RESULTS
legend info...
region info...
element info...

currently:

legend info...
<nothing>
region info...
!1 o_x o_y o_z w h t s_x s_y s_z r_x r_y r_z
updated n data...
<repeat>
0
element info...
!1
x_1 y_1 z_1 σ_{11} ... σ_{19} δ_{x1} δ_{y1} δ_{z1}
...
x_9 y_9 z_9 σ_{91} ... σ_{99} δ_{x9} δ_{y9} δ_{z9}
<repeat>
0

Fields

!	optional, if present region or element is hidden
o_x o_y o_z	origin of the region
w h t	width, height and thickness of the region (*t* is currently always 0)
s_x s_y s_z	grid spacing
r_x r_y r_z	rotation
updated	1 if region is updated, 0 if not
n	number of values to follow (omit this field if *updated* = 0)
data...	n floating point values (omit this field if *updated* = 0)
x_i y_i z_i	location of i^{th} function node
σ_{ij}	j^{th} stress value at i^{th} function node
δ_{xi} δ_{yi} δ_{zi}	displacement at i^{th} function node

END

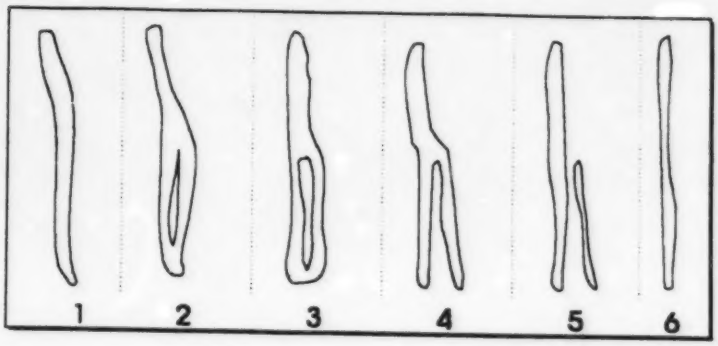
Desc. Specify end of file. This must be the last section in the file.

Format :END

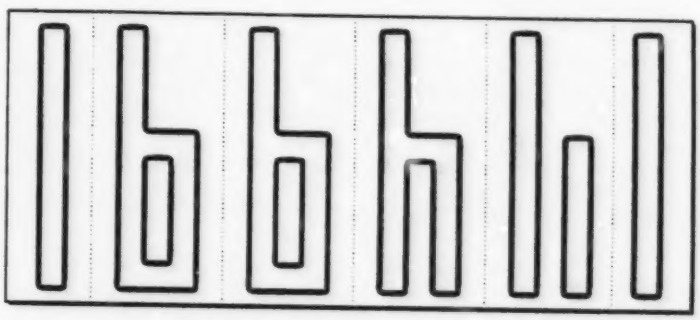
12. EXAMPLES

12.1 Ore body definition

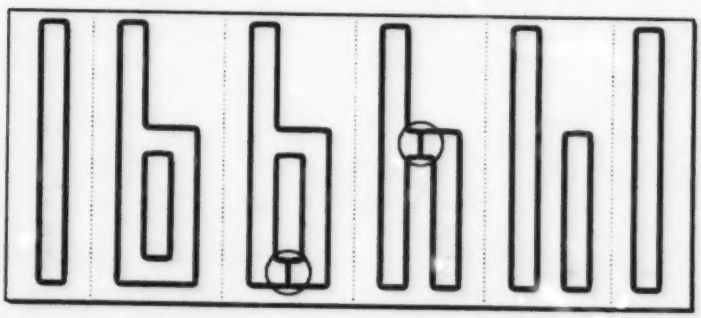
For this example it is assumed that the following ore body edges were digitized from sections. The spacing of the sections is assumed to be regular and the sections are assumed to be parallel.



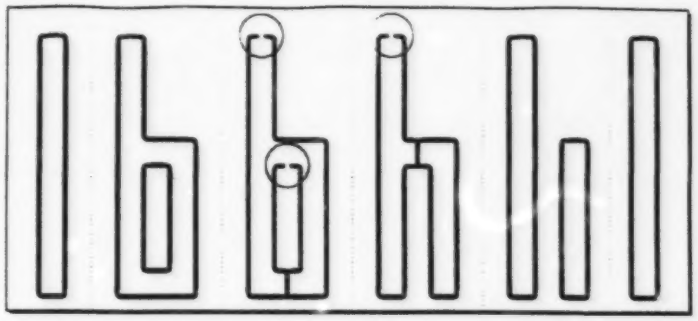
To simplify the geometry a more symbolic representation of the edges will be used.



To allow for the transition from section 3 to section 4 an extra edge must be created allowing for the topological change. Similarly section 4 must have an additional edge to allow for the changes between sections 4 and 5.

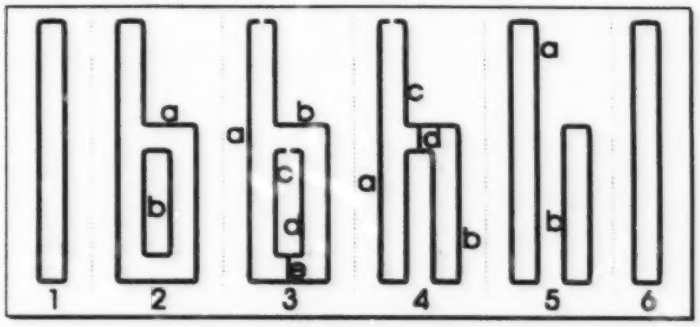


The mesh generator does not consider the order in which the edge set is created. It is therefore necessary to break the edges defining section 3 at the indicated locations to remove the confusion that will likely result. Section 4 must also be broken as indicated to accommodate for section 3.



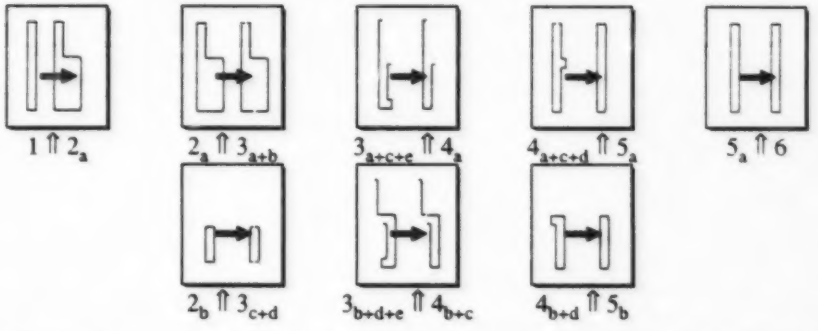
Patches

Once the edges are complete, patches can be created between the various sections



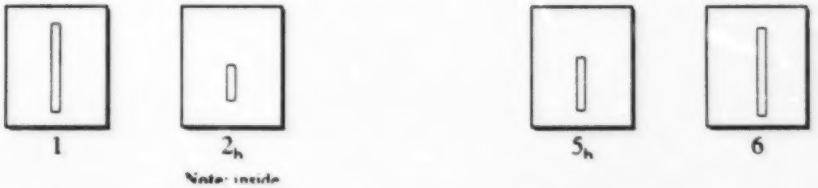
Side Patches

The side patches that must be made are as follows:



Cap Patches

The cap patches that must be made are as follows:



The patches shown above illustrate one possible way to define the ore body. These patches may have to be broken down into smaller patches if the mesh generator has problems creating the desired appearance. The problems that the mesh generator may have will depend on the geometry of the real model.